AGC-4 Mk II

Generator add-on protection package

Option C2

4189341344B

DEIF Improve Tomorrow

1. General information

1.1 Warnings, legal information and safety

1.1.1 Factory settings

The unit is delivered from the factory with default settings. These are not necessarily correct for the engine/generator set. Check all the settings before running the engine/generator set.

1.1.2 Legal information and disclaimer

DEIF takes no responsibility for installation or operation of the generator set. If there is any doubt about how to install or operate the engine/generator controlled by the Multi-line 2 unit, the company responsible for the installation or the operation of the set must be contacted.

NOTE The Multi-line 2 unit is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

Disclaimer

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The English version of this document always contains the most recent and up-to-date information about the product. DEIF does not take responsibility for the accuracy of translations, and translations might not be updated at the same time as the English document. If there is a discrepancy, the English version prevails.

2. Description of option

2.1 Scope of option C2

Option C2 is a standard software option for AGC-4 Mk II. It does not require any hardware apart from the standard-installed hardware.

This description of options covers SW version 6.00.0 or later.

Functions

Function	AGC-4 Mk II
Positive, negative and zero sequence	•
State state alternator reactive power capability curve (without limiter)	•
Alternator reactive power capability curve with limiting	•
Inverse time over-current	•

2.2 ANSI numbers

Protection	ANSI no.
Negative sequence current	46
Negative sequence voltage	47
Zero sequence current	$51I_0$
Zero sequence voltage	$59U_0$
Power-dependent reactive power	40
Inverse time over-current	51

2.3 Parameters

Option C2 relates to parameters 1080-1090, 1540-1590, and 1740-1790.

More information
See the **AGC-4 Mk II Parameter list**, document number 4189341273.

3. Function description

3.1 Positive, negative and zero sequences

3.1.1 Voltage vector system

The measurements of the generator currents and voltages are split up in three theoretical systems:

- The positive sequence system, with a positive direction of rotation.
- The negative sequence system, with a negative direction of rotation.
- The zero sequence system, with a positive direction of rotation.

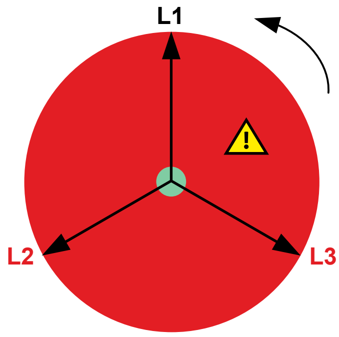
The voltages and currents in the positive sequence system are desirable, because they can be used by the consumers.

3.1.2 Negative sequence voltage (ANSI 47)

Negative sequence voltages arise when the virtual representation of the phase rotation for an unbalanced system appears negative.

Negative sequence voltages can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-to-phase or phase-to-neutral loads.

The alarm response is based on the estimated phase-to-neutral voltage phasors, as measured from the source.



Parameter	Text	Range	Default
1550	Set point	1 to 100 % of nominal voltage	5 %
	Timer	0.1 to 100 s	0.5 s
	Fail class	Fail classes	Trip MB
	Enable	Not enabled, Enabled	Not enabled
1561	Neg. seq select*	G measurement BB measurement	G measurement

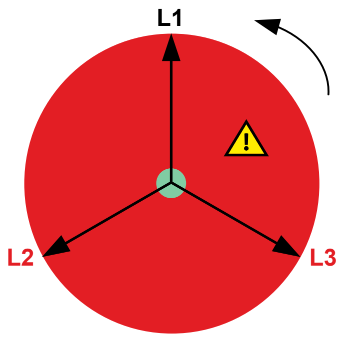
NOTE * Selection between generator or busbar measurement of negative sequence voltage.

3.1.3 Negative sequence current (ANSI 46)

Negative sequence currents arise when the virtual representation of the phase rotation for an unbalanced system appears negative.

Negative sequence currents can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-phase or phase-neutral loads.

This protection is used to prevent the generator from overheating. Negative sequence currents produce a magnetic field in the generator counter-rotating to the rotor. This field crosses the rotor at twice the rotor velocity, inducing double-frequency currents in the field system and in the rotor body.



The alarm response is based on the estimated phase-to-neutral current phasors, from the source, as measured by the controller.

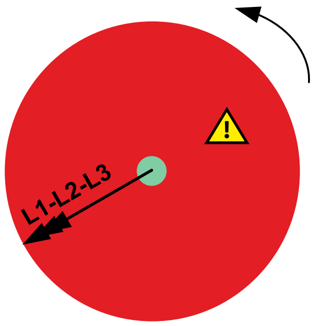
Parameter	Text	Range	Default
1540	Set point	1 to 100 % of nominal current	20 %
	Timer	0.1 to 100 s	0.5 s
	Fail class	Fail classes	Trip MB
	Enable	Not enabled, Enabled	Not enabled

3.1.4 Zero sequence voltage (ANSI 59Uo)

Zero sequence voltages arise when the phases rotation is positive, but the vector zero value (star point) is displaced. This zero sequence voltage protection can be used instead of using zero voltage measurement or summation transformers (zero sequence transformers).

This protection is used for detecting earth faults.

The alarm response is based on the estimated phase-to-neutral voltage phasors, as measured from the source.



Parameter	Text	Range	Default
1580	Set point	1 to 100 % of nominal voltage	5 %
	Timer	0.1 to 100 s	0.5 s
	Fail class	Fail classes	Trip MB
	Enable	Not enabled, Enabled	Not enabled
1591	Zero seq select*	G measurement BB measurement	G measurement

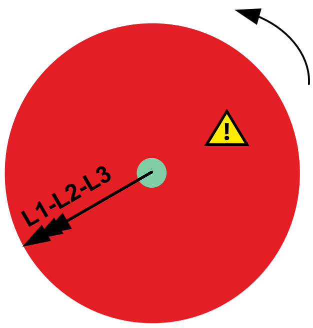
NOTE * Selection between generator or busbar measurement of zero sequence voltage.

3.1.5 Zero sequence current (ANSI 51Io)

Zero sequence currents arise when the phases rotation is positive, but the vector zero value (star point) is displaced.

This protection is used for detecting earth faults.

The alarm response is based on the estimated phase-to-neutral current phasors from the source, as measured by the controller.



Parameter	Text	Range	Default
1570	Set point	1 to 100 % of nominal current	20 %
	Timer	0.1 to 100 s	0.5 s

Parameter	Text	Range	Default
	Fail class	Fail classes	Trip MB
	Enable	Not enabled, Enabled	Not enabled

3.2 Power-dependent reactive power (Capability curve)

3.2.1 Alternator capability curve

This curve indicates the possible reactive load at any given power load for the generator in question, for exporting and importing reactive power.

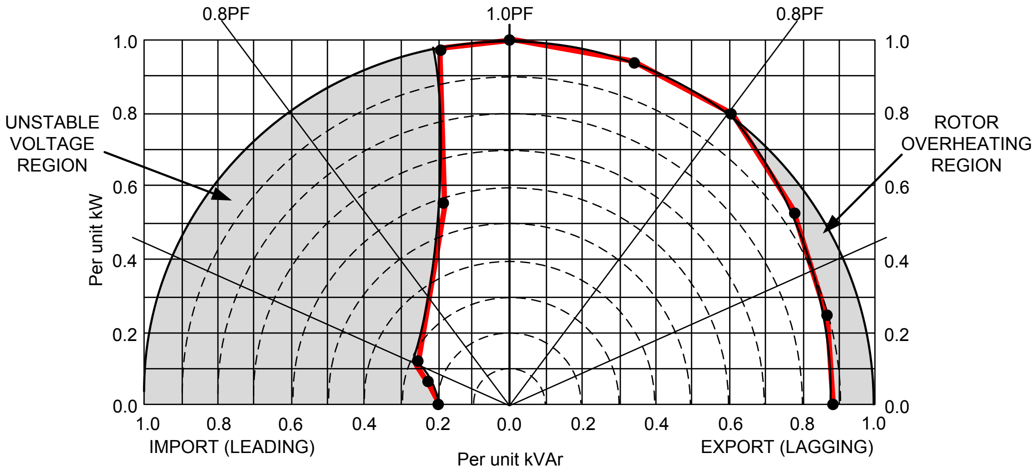
As the reactive power varies in a non-linear way with actual (power) load, the setting of trip values is made with a 12-point curve, six for lagging and six for leading reactive power. The controller does a linear regression between any two given points in order to find the trip point between the curve point settings.

Each of the 12 points has a setting for real power (P) and a setting for the related reactive power (Q).

The parameters for this protection are 1740-1790. For more detailed information, see the parameter list.

3.2.2 Setting curves

STEADY STATE ALTERNATOR REACTIVE POWER CAPABILITY CURVE



The settings of points 1-6, leading and lagging, should represent the generator manufacturer's recommended settings for var import (-Q)/export (+Q). Notice that the above curve is just an example, the actual values must be obtained from the generator manufacturer.

NOTE It is imperative that the generator does not enter any of the grey areas. If it does, rotor overheating (export) or loss of synchronism (import) may occur.

NOTE In the above diagram, the positive power/reactive power flow direction is defined as the direction from the generator to the consumer, that is increasing export (lagging) is equal to increasing excitation.

3.3 Capability curve

3.3.1 Alternator capability curve with limiting

Active power-dependent reactive power limiting is a generator protection feature which is part of option C2. It limits the reactive power production relative to actual power production.

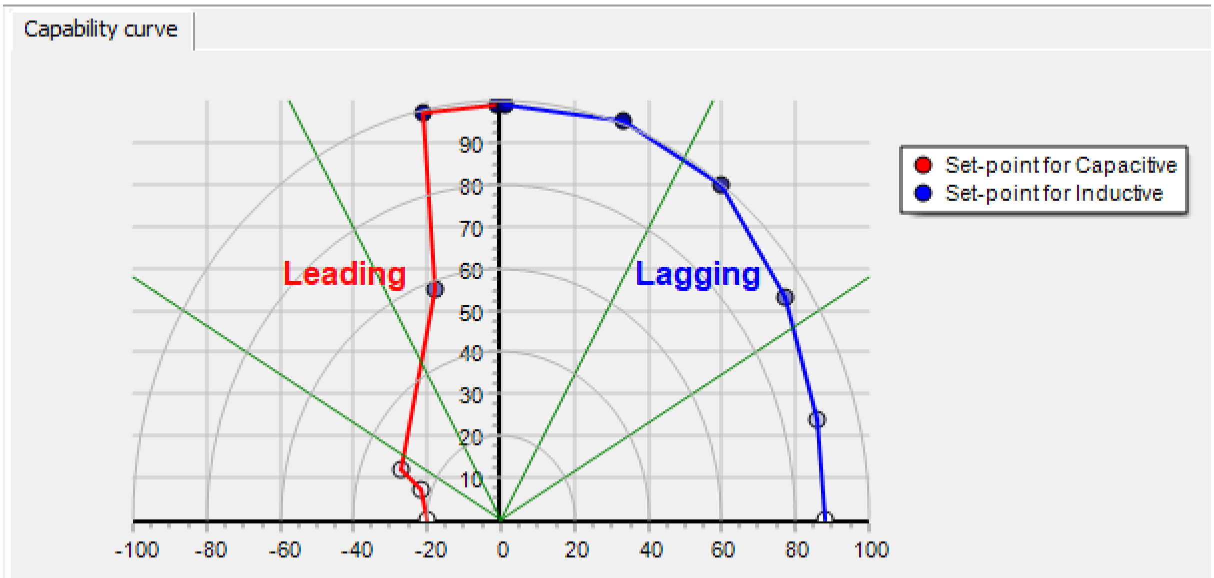
Active power-dependent reactive power limiting can use the generator steady state reactive power capability curve. The actual curve depends on the generator. The curve should be included in the generator's data sheet. Contact the generator manufacturer to get this information.

To activate the reactive power limitation based on the capability curve, set *AVR limiting type*, parameter 2811, to *Capability curve Q*.

NOTE Configure the alarms in the parameter list. Use *G P dep. Q<*, parameter 1761, for import, and *G P dep. Q>*, parameter 1791, for export.

The curves are configured under *Advanced Protection*, *Capability curve*. Six active power and reactive power co-ordinates define the curve for import of reactive power. Similarly, six co-ordinates define the curve for export of reactive power.

Example of generator capability curve from the USW



If the set point for reactive power is outside the limiting curve, the controller restricts the reference to the regulator. When the reactive power set point moves inside the limiting curve, the controller regulates reactive power (or cos phi).

Protections can also be activated to disconnect the generator from the grid. Use menu 1760 to configure an alarm for exceeding the capability curve under the excitation limit. Use menu 1790 to configure an alarm for exceeding the capability curve over the excitation limit.

The *AVR lim. setpoint*, parameter 2812, defines when regulation is stopped. If this parameter is *100 %*, the controller regulates all the way to the capability curve. For *95 %*, regulation stops at 5 % away from crossing the limit curve.

S nominal(import) (1766) and *S nominal(export) (1796)* under *Advanced Protection*, *Capability curve*, define the limit of the y-axis. It can relate to active power (P/Q diagram) or apparent power (S/Q diagram).

Example of apparent and active power for the capability curve

The generator has a 1000 kW nominal power and a 1250 kVA nominal apparent power.

For an S/Q diagram as the capability curve, use 1250 kVA for the *S nominal* settings (under *Advanced Protection*, *Capability curve*). On the capability curve, 100 % of nominal apparent power is then 1250 kVA.

Alternatively, for a P/Q diagram as the capability curve, use 1000 kVA for the *S nominal* settings. On the capability curve, 100 % of nominal power is then 1000 kW.

The VDE rules refer to a P/Q diagram. Most generator manufacturers provide an S/Q diagram. To meet the VDE rules, use the nominal active power (in kW) in the *S nominal* settings.

3.3.2 Parameters for capability curve

These parameters and settings define the active power-dependent reactive power limiting.

The settings are configured under *Advanced Protection*, *Capability curve*.

Set-point for Capacitive (Under-excited; Absorption) **(red curve)**

Reactive power	Default	Active power	Default
G P dep Q<Q1	20 %	G P dep P<P1	0 %
G P dep Q<Q2	22 %	G P dep P<P2	7 %
G P dep Q<Q3	27 %	G P dep P<P3	12 %
G P dep Q<Q4	18 %	G P dep P<P4	55 %
G P dep Q<Q5	21 %	G P dep P<P5	97 %
G P dep Q<Q6	1 %	G P dep P<P6	99 %

Set-point for Inductive (Over-excited; Injection) **(blue curve)**

Reactive power	Default	Active power	Default
G P dep Q>Q1	88 %	G P dep P>P1	0 %
G P dep Q>Q2	86 %	G P dep P>P2	24 %
G P dep Q>Q3	77 %	G P dep P>P3	53 %
G P dep Q>Q4	60 %	G P dep P>P4	80 %
G P dep Q>Q5	33 %	G P dep P>P5	95 %
G P dep Q>Q6	1 %	G P dep P>P6	99 %

AVR limiting type**, parameter 2811**

Set point	Default	Description
OFF		The controller does not limit the regulation of cos phi or reactive power.
Droop curve	•	Depending on which regulator is active, the controller limits the regulation. For cos phi, the controller uses settings *Cosphi min set* and *Cosphi max set* (under *Advanced Protection*, *Droop curve 2*, *Cosphi curve*). For reactive power, the controller uses settings *Q min* and *Q max* (under *Advanced Protection*, *Droop curve 2*, *Q curve*).
Capability curve Q		The controller limits the regulation using the parameter settings for power-dependent reactive power limiting.

AVR lim. setpoint**, parameter 2812**

Default	Range	Description
95 %	20 to 100 %	The cos phi/reactive power regulation stop with respect to the capability curve

Scaling, parameter 9030, determines which *S nominal* the controller uses. The setting for the default scaling is shown below.

S nominal* for *100-25000V

Setting	Default for 100-25000V	Range for 100-25000V	Description
S nominal	600 kVA	10 to 32000 kVA	Nominal apparent power

3.4 Inverse time over-current

3.4.1 Formula and settings used

The inverse time over-current is based on IEC 60255 part 151.

The function used is **dependent time characteristic,** and the formula used is:

$$t(G) = TMS \left(\frac{k}{\left(\frac{G}{G_S} \right)^{\alpha} - 1} + C \right)$$

where

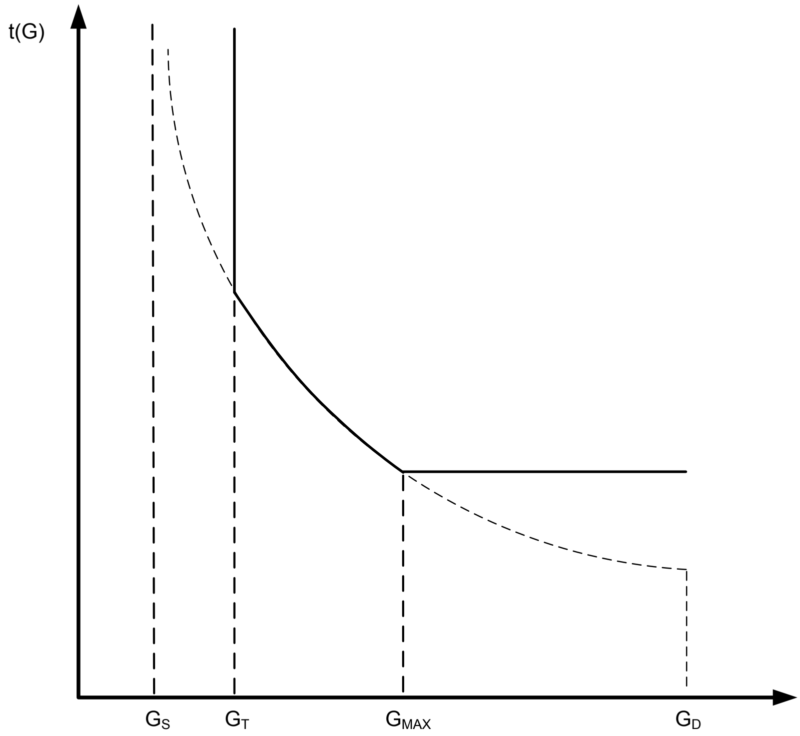
t(G)	is the theoretical operating time constant value of G in seconds
k, c, α	are the constants characterising the selected curve
G	is the measured value of the characteristic quantity
G_S	is the setting value
TMS	is the time multiplier setting

The constants k and c have a unit of seconds, α has no dimension.

NOTE There is no intentional delay on reset. The function will reset when $G < G_S$.

3.4.2 Curve shapes

Time characteristic:



$G_S = I_{nom}$ x LIM

$G_T = 1.1$ x G_S

G_{MAX} = Over-current factor x CT_P

$G_D = 20 * G_S$

Abbreviation explanation

G_T	Minimum trip current
G_{MAX}	Maximum trip current
I_{nom}	Nominal current setting
CT_P	Connected current transformer primary side value
G_D	The point where the alarm shifts from an inverse curve to a definite time characteristic
t_{MIN}	Minimum trip time that can be used for protection purpose. Only a calculation can show if this value will interfere with the intended trip curve

Over-current factor	t_{MIN}
2.2	250 ms

There is a choice between seven different curve shapes, of which six are predefined and one is user-definable:

IEC Inverse

IEC Very Inverse

IEC Extremely Inverse

IEEE Moderately Inverse

IEEE Very Inverse

IEEE Extremely Inverse

Custom

Common settings for all types:

Setting	Parameter no.	Factory setting value	Equals
LIM	1082	110 %	LIM = G_S/ I_{nom}
TMS	1083	1.0	Time multiplier setting

The following constants apply to the predefined curves:

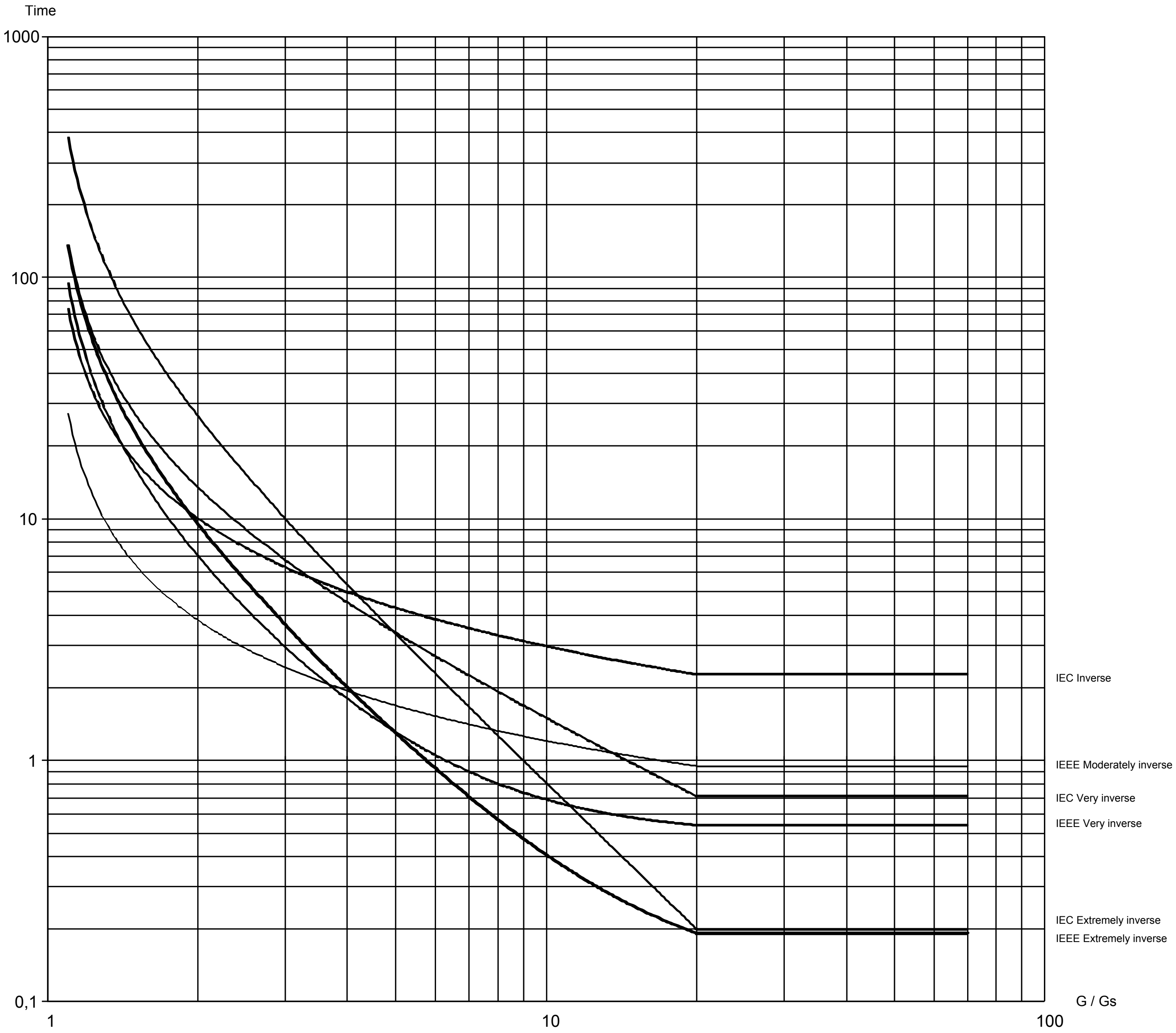
Curve type	k	c	α
IEC Inverse	0.14	0	0.02
IEC Very Inverse	13.5	0	1
IEC Extremely Inverse	80	0	2
IEEE Moderately Inverse	0.0515	0.1140	0.02
IEEE Very Inverse	19.61	0.491	2
IEEE Extremely Inverse	28.2	0.1217	2

For the custom curve, these constants can be defined by the user:

Setting	Parameter no.	Factory setting value	Equals
k	1084	0.140 s	k
c	1085	0.000 s	c
α	1086	0.020	α

NOTE For the ranges, see the parameter list.

3.4.3 Standard curves



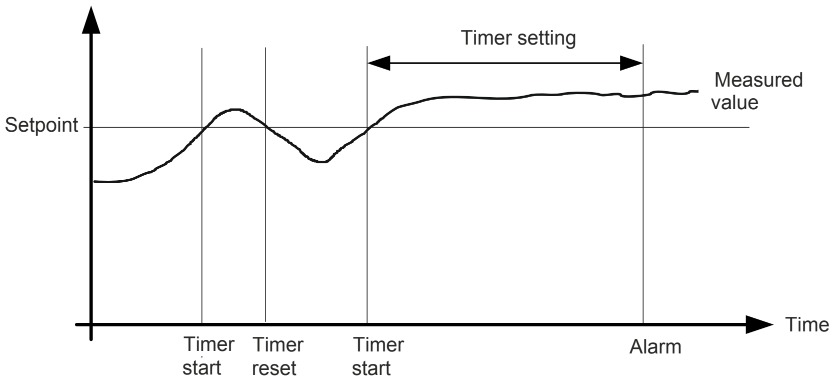
NOTE The curves are shown for TMS = 1.

4. Alarms

All settings are stated in percent of the nominal generator value.

The delay settings are (with a few exceptions, for example inverse time over-current) of the definite time type, that is a set point and time is selected.

If the function is for example over-voltage, the timer will be activated if the set point is exceeded. If the voltage value falls below the set point value before the timer runs out, the timer will be stopped and reset.



When the timer runs out, the output is activated. The total delay will be the delay setting + the reaction time.